HEADACHE DOES NOT PREDICT SIDELINE NEUROSTATUS OR BALANCE IN HIGH SCHOOL FOOTBALL PLAYERS

BY

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THESIS

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Headache Does Not Predict Sideline Neurostatus or Balance in High School Football Players

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Context: Headache is reported to be the most common concussion related symptom. This has resulted in a heavy reliance on symptoms for the sideline assessment of concussive injuries. It is unclear however, if all athletes reporting headache demonstrate impairment in other commonly evaluated concussion domains. **Objective**: To determine the relationship between those with and without a headache resulting from football participation on neurostatus and balance. **Design:** A two group repeated-measures design. **Setting**: Three high schools in central Illinois. **Participants:** Varsity football athletes (N=32; age 16.3±0.8 years, range 16-18; weight 82.8±21.8 kg; height 177.0±7.5 cm), participated in this study. **Interventions:** All athletes completed a baseline evaluation of the Graded Symptom Checklist (GSC), Balance Error Scoring System (BESS) and Standardized Assessment of Concussion (SAC). Athletes reporting a headache (n=16) following a game or practice were re-administered the same test battery, as well control participants (non-headache: n=16) matched for age, playing position, weight and height. **Main Outcome Measures:** Performance on the GSC, BESS and SAC were evaluated using group by time repeated measures analysis of variance. Significance was noted when $p<0.05$. **Results:** Following football participation, total GSC scores increased significantly (p=.004) in the headache group (8.1±8.9 to 16.1±15.3), but significantly decreased (p=.01) in the non-headache group (6.1±7.0 to 3.1±4.4). A significant decrease (p<.000) in BESS performance was noted in both groups: headache (15.0±7.4 to 20.3±8.9) and non-headache (13.3±6.7 to 18.1±6.7). No significant differences were noted on SAC performance (p>0.05). **Conclusions:** Performance on common concussion assessment tools does not appear to be influenced by athlete reports of football related headache. These findings indicate that the use of headache, exclusively or in combination with other concussion related symptoms, is not a valid marker of the injury. This supports previous works suggesting clinicians should adopt a multifaceted approach to concussion management. Further, physical exertion appears to have an effect on BESS performance independent of symptoms, suggesting careful interpretation of BESS scores when administered on the sideline.

To my family, friends, and best friend. Without their eternal love, encouragement, patience and support, this never would have been possible.

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CHAPTER 1: INTRODUCTION

A concussion is a complex pathophysiological process that affects the brain, and induced by traumatic biomechanical forces (Aubry et al., 2002; McCrory et al., 2009). It is estimated that between 1.6 and 3.8 million sport-related concussions occur each year in the United States (Langlios, Rutland-Brown, Wald, 2006). Second only to motor vehicle accidents, sports, especially football, is one of the leading causes for traumatic brain injuries in people age 15 to 24 years old (Sosin, Sniezek, Thurman, 1996).

The National Athletic Trainers' Association recommends that any athlete suspected of having a concussion be administered a clinical exam with tests of neurocognitive functioning, postural control and athlete reported symptoms used to support the diagnosis (Guskiewicz et al., 2004). Symptoms of a concussion vary between individuals; however, the most commonly reported symptom is headache. Eighty-six percent of high school and college athletes report a headache following a concussion (Guskiewicz, Weaver, Padua, Garrett, 2000). In many instances though, it is not uncommon for athletes to develop a headache while participating in athletics, especially if they are participating in a contact sport. Indeed, athletes may experience headache and other concussion like symptoms in the absence of injury (Williams & Nukada, 1994). Headaches are due to many factors such as muscle tension, frustration, dehydration, exercise, as well as forces acting on the head/body and causing injury to the brain. In fact, 35% of athletes report experiencing exercise related headaches (Williams & Nukada, 1994). These data provide conflicting information in regards to the management of a suspected concussive injury. Regardless, proper medical care would dictate that those reporting symptoms would necessitate further assessment to rule out concussion.

The Standardized Assessment of Concussion (SAC) is a brief neurostatus exam that can be quickly administered by medical personnel on the sideline to aid in the concussion diagnosis. The Balance Error Scoring System (BESS) is a measure of postural control that can similarly be administered on the sideline. The Graded Symptoms Checklist (GSC) uses a Likhert scale to assess the presence and severity of symptoms. A one point decrease in a SAC exam from baseline testing to post-injury (Barr & McCrea, 2001) or performing three or more errors during a BESS exam has been shown to be significant enough to diagnose a concussion (Valovich McLeod, Barr, McCrea, Guskiewicz, 2006). When used in conjunction immediately following injury, the GSC, SAC, and BESS are 94% sensitive to concussion (McCrea et al., 2005).

Although the existing literature indicates that concussions nearly always result in headache, it is unknown if headache is always indicative of injury. Headaches experienced by athletes can be caused by a variety of factors such as muscle contraction or general activity. In fact muscle contraction or tension type headaches are the most common and can account for up to 70% of all headaches (Dimeff, 1992). Further, Williams and Nukada (1994) reported that 71% of sport related headaches were not due to trauma with the majority being related to effort-exertional type headaches. Others have shown that concussed individuals have the same occurrence, type, and severity of headaches as those with only minor orthopaedic injuries not involving the head or neck (Stovner, Schrader, Mickevičiene, Surkiene, Sand, 2009).

Therefore, the purpose of this investigation is to elucidate the relationship between headache resulting from interscholastic football participation and athlete reports of concussion like symptoms (ie The Graded Symptoms Checklist (GSC)), postural control (BESS) and neurostatus (SAC).

Hypothesis: Athletes who report a headache following exercise will experience no significant change on the neurocognitive and balance tasks than at baseline as well as in their reported symptoms. This hypothesis is also in reference to their matched counterparts who do not report a headache, with respect to age, weight, height and position played.

CHAPTER 2: LITERATURE REVIEW

"Concussion is defined as a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces. Several common features that incorporate clinical, pathological, and biomechanical injury constructs that may be used in defining the nature of a concussive head injury include: (1) Concussion may be caused by a direct blow to the head, face, neck, or elsewhere on the body with an "impulsive" force transmitted to the head; (2) Concussion typically results in the rapid onset of short lived impairment of neurological function that resolves spontaneously; (3) Concussion may result in neuropathological changes but the acute clinical symptoms largely reflect a functional disturbance rather than structural injury; (4) Concussion results in a graded set of clinical symptoms that may or may not involve loss of consciousness. Resolution of the clinical and cognitive symptoms typically follows a sequential course; however, it is important to note that, in a small percentage of cases, post-concussive symptoms may be prolonged; (5) No abnormality on standard structural neuroimaging studies is seen in concussion," (McCrory et al., 2009).

Numerous concussion grading scales exist to determine the severity of concussions. Most scales focus on loss of consciousness (LOC) and amnesia for diagnosis (Cantu, 1988), with the revised Cantu focusing strictly on posttraumatic amnesia (Cantu, 2001). However, in a study performed on high school and collegiate football players, LOC was reported in only 8.9% of the cases and amnesia in 27.7% (Guskiewicz et al., 2000). Headache was reported in 86% which suggests that symptoms other than LOC and amnesia are needed to more accurately diagnose a concussion (Guskiewicz et al., 2000). Headache, dizziness, nausea, vomiting, balance problems, fatigue, trouble sleeping, drowsiness, sensitivity to light or noise, blurred vision, amnesia, confusion or disorientation are all symptoms typically involved with diagnosis (Giza & Hovda, 2001; Guskiewicz et al., 2004; Quality Standards Subcommittee, 1997). The NATA's position statement on concussions, which may be referred to as a mild traumatic brain injury (mTBI), says that if an injury to the head occurs and one or more of the conditions listed above result, it is then classified a concussion. Of the symptoms listed, a headache is the most frequently reported in relation to an MTBI (Packard, 1999; Gessel, Fields, Collins, Dick, Comstock, 2007). In 2003, one study found that headache was reported 85.2% of the time in association with a concussion (Guskiewicz et al., 2003). Since headaches are the number one reported symptom of a concussion, it is important to determine the role that they have in the diagnosis of an MTBI as well as return to play decisions (Register-Mihalik, Guskiewicz, Mann, Shields, 2007).

High school athletics currently consists as the largest athletic population in the United States with almost 7.2 million participants and over 1 million of them football athletes (National Federation of State High School Associations [NFHS], 2006). Many studies have been performed on this population to obtain an accurate estimate of injuries that are occurring to their developing brain. In a study by Gessel et al. (2007), 8.9% of all injuries sustained by athletes at 9 high schools were concussions. Another study conducted on 10 high schools reported 5.5% of all injuries to be mTBIs (Powell & Barber-Foss, 1999). Football had the highest incidence of concussions in both studies at 40.5% (Gessel et al., 2007) and 63.4% (Powell & Barber-Foss, 1999) respectively. Linebackers (Gessel et al., 2007; Guskiewicz, et al., 2003; Powell & Barber-Foss, 1999), running backs (Gessel et al., 2007; Powell & Barber-Foss, 1999), offensive linemen (Guskiewicz, et al., 2003; Powell & Barber-Foss, 1999) and defensive backs (Guskiewicz, et al., 2003) were the positions that received most of the injuries due to the tackling and being tackled nature of their position.

Although there currently is a range for the number of concussions that occur during high school football, trends are lower than what was reported prior to 1980. A study from 103 high school football teams in Minnesota in 1977 reported 24% of all injuries sustained were concussions (Gerberich, Priest, Boen, Straub, Maxwell, 1983). Researchers believe the decreased number of incidences is due to the implementation of the National Operating Committee for Safety in Athletic Equipment (NOCSAE) helmet protection standards in 1980 (Powell & Barber-Foss, 1999). Other suggestions for the current lower rate are: spearing was outlawed in 1976, player education on the effects of multiple concussions, reduction of physical contact time during practice, and clinician awareness of returning players to competition while symptomatic (Guskiewicz et al., 2000).

However, other researchers feel differently about why concussion trends have been on the decline since the 1980's. Many reports believe the number of concussions obtained throughout the US is higher than what is reported (Gessel et al., 2007). One study claimed that 15.3% of high school football players sustained a concussion in a given season, although only 47.3% of the injured athletes reported it (McCrea, Hammeke, Olsen, Leo, Guskiewicz, 2004). This was due to reasons such as the player did not think it was that serious, the player did not want to be taken out of the game, the player did not recognize the signs and symptoms of a concussion at the time, and the player did not want to let down teammates (McCrea et al., 2004).

Due to the aforementioned reasons, it is especially important for the testing of concussions to be effective. Numerous tests exist to assist in the diagnosis of a concussion;

however, some are more commonly used due to their ease of administration and not needing much, if any, equipment. According to the National Athletic Trainer's Association Position Statement: Management of Sport-Related Concussion, the SAC, BESS and GSC should be used as brief screening tools that support the clinical exam when evaluating for a possible concussion (Guskiewicz et al., 2004).

The SAC is one tool used to assist in testing for concussions. Its popularity is due to it being a quick and easy test that can be performed on the sidelines, and has the ability to test neurocognitive status (Koscs, Kaminski, Swanik, Edwards, 2009). It consists of four parts: orientation, immediate memory, concentration and delayed recall. The test uses a 0 to 30 scoring system where lower scores indicate neurocognitive impairment (McCrea, Kelly, Randolph, 2000). As with all concussion tests, the test SAC should be performed at baseline to provide individualized comparison with the post-injury assessment up to 72 hours.

This test has been proven to be effective in detecting concussions as well as when it is used as a tool to determine return to play status (McCrea et al., 2000; McCrea et al., 1998). Even though the test is based on a possible 30 point scale, researchers found that a drop in 1 point from baseline was enough to separate concussed from non-concussed athletes with approximately 95% sensitivity (McCrea, 2001) and 76% specificity (Barr & McCrea, 2000; McCrea, 2001). This high level of sensitivity and specificity support other researchers' work on the reliability and validity of the SAC test in the ability to detect an altered mental status (McCrea et al., 2003). The SAC test was also found to be reliable after an acute bout of exertional exercise (Koscs et al., 2009). Alternate forms of the SAC test are available; however it has been proven to not elicit a practice effect after repeated attempts (Valovich, Perrin, Gansneder, 2003; Valovich McLeod et al., 2004).

Since decrements to balance are well noted following concussion, the BESS was developed as a sideline assessment to detect changes in balance following a suspected injury (Guskiewicz, 2001; Guskiewicz, Ross, Marshall, 2001). It is used to measure postural control and stability (Riemann, Guskiewicz, Shields, 1999). The test is performed by having the subject stand on both firm and foam surfaces, in three different stances, double leg, single leg and tandem (toe to heal) (Riemann et al., 1999). The non-dominant leg should be used for the single leg stance, and the dominant leg should be placed ahead of the non-dominant for the tandem stance (Riemann et al., 1999). Leg dominance can be determined by asking which leg the athlete chooses to kick a ball with (Riemann & Guskiewicz, 2000). Subjects are then instructed to keep their hands on top of their iliac crests, head up and both eyes closed while holding each designated stance for 20 seconds (Riemann et al., 1999).

The test is scored by measuring errors while attempting balance. One point is added per error while attempting the test. Errors include: opening the eyes, stumbling or falling out of position, removing the hands from the hips, moving the hip into more than 30° of flexion or abduction, lifting the forefoot or heel or remaining out of the test position for longer than 5 seconds (Riemann et al., 1999). An increase of three or more errors from baseline to post-injury testing is indicative of balance impairment (Valovich McLeod et al., 2006).

Numerous studies have been conducted and found that intertester and intratester reliability coefficients for the BESS test ranged from 0.78 to 0.96 (Riemann et al., 1999) and

0.87 to 0.98 (Valovich McLeod et al., 2004) respectively, making this a reliable test for postural control. However, the test-retest reliability has been found to decrease after repeated testing. In a study by Valovich et al. (2003), subjects were tested on day one (baseline), three, five and seven. The number of errors performed by the subjects decreased with each repeated session. In addition, the total errors on day five and seven were lower than initial baseline testing, which shows that the BESS test may elicit a practice effect over repeated attempts (Valovich et al., 2003).

Furthermore, researchers have questioned the reliability of the BESS test after exercise. Studies show that the postural control is negatively affected immediately following activity and can take up to 20 minutes before performance can be restored to baseline levels (Susco, Valovich McLeod, Gansneder, Shultz, 2004; Wilkins, Valovich, Perrin, Gansneder, 2004). However, a more recent study performed by Fox et al. shows that balance can be restored as early as 13 minutes post exercise (Fox, Mihalik, Blackburn, Battaglini, Guskiewicz, 2008). Nevertheless, all of the studies still support the use of the BESS test but only after a period of rest.

Another form of concussion testing involves the use of a symptom scale to determine the presence and severity of symptoms the athlete is experiencing. The GSC is completed by the athlete initially following a concussion. It uses a Likert ranking with the lowest number signifying the athlete is not experiencing any symptoms and the highest meaning the symptoms are very severe. Common symptoms included in the checklist are: blurred vision, dizziness, drowsiness, excess sleep, easily distracted, fatigue, feeling “in a fog”, feeling “slowed down, headache, inappropriate emotions, irritability, loss of consciousness, loss of orientation, memory problems, nausea, nervousness, personality change, poor balance, poor concentration, ringing in ears, sadness, seeing stars and sensitivity to light (Guskiewicz et al., 2004). Typically the athlete will repeat the GSC every 24 hours following injury to determine if the symptoms are worsening or not.

However, dehydration may cause an increase in symptoms which can mislead clinicians and/or possibly misdiagnose concussions. A recent study performed by Patel et al. (2007) showed that athletes who were dehydrated and performed exercise reported symptoms similar to those seen in concussion cases (Patel, Mihalik, Notebaert, Guskiewicz, Prentice). The most common symptoms reported were: feeling slowed down (91.7%), fatigue/drowsiness (91.7%), difficulty concentrating (85.5%), balance problems (75.0%), dizziness (54.2%), and headache (50.0%) (Patel et al., 2007). It is believed that the headache may have resulted from intracranial dehydration affecting the meninges and brain (Blau, Kell, Sperling, 2004). In a study involving 34 patients suffering from a water-deprivation headache, it took less than 30 minutes for 22 of the subjects to feel completely symptom free after rehydrating (Blau et al., 2004). More research needs to be done on this type of headache, but impaired concentration and irritability can also be symptoms of water-deprivation. These findings warrant that the GSC aid in the detection for concussions but not be the only tool used.

Studies have shown that self-reported symptoms scales provide both factorial and construct validity, therefore making the GSC a simple and efficient means of detecting a concussion and assisting with return to play decisions (Piland, Motl, Ferrara, Peterson, 2003; Piland, Motl, Guskiewicz, McCrea, Ferrara, 2006). This is true even with young athletes when the wording presented in the checklist is easy to understand and not misleading (Mailer, Valovich McLeod, Bay, 2008; Valovich McLeod, Bay, Heil, McVeigh, 2008). Nevertheless, since this is a self-reporting and subjective test, caution should be used due to the possibility of athletes trying to mask or repress true symptoms.

Headaches

As previously reported, concussion nearly always results in headache but it is unknown if a headache is always indicative of injury. Headaches experienced by athletes can be caused by a variety of factors with some being more serious than others. Dr. Dimeff (1992) lists these factors as: intracranial hemorrhage, meningitis/encephalitis, tumor, hypertension, infection, vascular, muscle contraction, posttraumatic and activity-related. Muscle contraction or tension type headaches are the most common and can account for up to 70% of these types of headaches (Dimeff, 1992).

In many instances however, athletes may experience headache and other concussion like symptoms in the absence of injury (Williams & Nukada, 1994). Williams and Nukada (1994) found that 71% of sport related headaches were not due to trauma with the majority being related to effort-exertional type headaches. These types of headaches can be due to many factors; however, increased intracranial pressure, such as the Valsalva maneuver, and vascular headaches, which are commonly seen in poorly conditioned athletes, tend to be more common (Dimeff, 1992).

A recent study from Lithuania used data from trauma patients reporting to the ER. Data showed that patients who came in with a concussion had the same occurrence, type, and severity of headaches as those with only minor orthopaedic injuries not involving the head or neck (Stovner et al., 2009). The authors suggested that socioeconomic status played more of role in the headache than the concussion itself.

According to the International Headache Society (IHS), there are currently 10 types of headaches that can be associated with exercise: migraine, tension-type headache, external compression headache, benign exertional headache, acute post-traumatic headache, high-altitude headache, hypercapnia headache, cervicogenic headache, effort headache and cardiac cephalgia (International Headache Society, 1988). Benign exertional headaches are categorized by a bilateral throbbing pain that lasts from 5 to 24 hours and is provoked by physical exercise (Green, 2001). In a study by Pascual et al. (1996), 57% of exertional headaches were found to be benign (Pascual, Iglesias, Oterino, Vázquez-Barquero, Berciano).

Headache plays an important role in return to play decision making. One study showed that all athletes who experienced a headache less than 3 hours were allowed to return to play after a minimum of 7 days, compared to only 58% whose headache lasted longer than 3 hours (Asplund, McKeag, Olsen, 2004). This proves that only persistent headaches are of important in the diagnosis of a serious concussion. Additionally, Collins et al. (2003) found that athletes experiencing post-concussive headache 7 days following an injury have more symptoms then concussed, non-headache athletes as well as slower reaction times and reduced memory performance. These results indicate that a headache following an injury is a significant reason to not allow an athlete to return to play prior to the resolution of symptoms, since it can be a sign of incomplete recovery.

The return to play guidelines for a concussion are similar to those suggested for a headache in that they error on the side of caution. According to the NATA's position statement, an athlete should only be allowed to return if he/she is completely symptom free as well has a normal neurologic examination, normal neuropsychological and postural-stability examinations and normal neuroimaging studies (Guskiewicz et al., 2004). Since it is not possible to perform all of these examinations and studies for each case, age, level of participation, risk of the sport and concussion history should all be used to consider each athlete on an individual basis.

Numerous studies exist to support this zero tolerance rule for the rest of the day for an athlete who is experiencing telltale concussion symptoms such as LOC, dizziness, amnesia and headache (Aubry et al., 2001; Cantu, 1997; Cantu, 2001; Wilberger & Maroon, 1989). Recent studies proving the significance of disqualification have found that even when a player's symptoms dissipate within 15 to 20 minutes post concussion, they may still show delayed symptoms or depressed neurocognitive levels later on. One study found that high school athletes who experienced a grade 1 concussion and were symptom free within 15 minutes post injury, displayed both memory deficits and increased symptoms 36 hours post injury (Lovell, Collins, Iverson, Johnston, Bradley, 2004). Another study involving collegiate athletes found that 33% (10/30) of the players who were allowed to return to play on the same day experienced delayed onset of symptoms 3 hours post injury, compared to only 12.6% (20/158) of athletes who did not return to play (Guskiewicz et al., 2003).

Determining return to play can vary on a case-by-case basis. One study suggests that athletes need an average of 4 days of rest before returning to play following a grade 1 concussion (Guskiewicz et al., 2000). However, most return to play guidelines are on the conservative side and suggest that athletes be symptom free for at least seven days before resuming activity (Quality Standards Subcommittee, 1997; Cantu 2001). Even more conservatively, one study suggests that the brain needs four to six weeks for complete healing to take place and to protect it from re-injury (Mayors, 2008). However, if this was the case, most concussions would therefore be a season-ending injury and athletes would be more hesitant to report symptoms.

The need for a period of rest after symptoms subside is to be sure that the athlete's brain is completely healed so that further complications do not develop. If an athlete returns to play before the complete healing of a concussion occurs and sustains another mild blow, a more serious and life threatening condition known as second impact syndrome (SIS) may transpire (Cantu, 2001). SIS has a mortality rate of nearly 50% and is usually due to concussions that were not diagnosed or treated properly before an athlete returns to play (Cantu, 1998).

CHAPTER 3: METHODS

Subjects were comprised of varsity football players from three high schools located in the central Illinois area. Athletes ranged from 16 to 18 years of age. Subjects allowed to participate in the study completed an inclusion/exclusion form and consent and assent form (see Appendixes A, B and C). All participants read and signed a University of Illinois Institutional Review Board informed consent document prior to testing. Preseason measurements of height, weight, and primary position played were recorded prior to the start of the season. This information was used to match players of the same demographic information for comparison between an athlete experiencing a headache and one that was not. Subjects were matched in order of importance: age, position played, weight and height. The control subjects ages were matched by year of birth, positions were matched by grouping subjects into skilled vs. lineman as well as offense vs. defense, weight was matched ± 20 pounds and height was matched ± 2 inches.

Baseline measurements of the GSC, SAC and BESS were administered prior to the start of the season. To decrease variability, the same individual administered either the BESS or SAC during baseline testing as well as at follow-up at each site. Subjects reporting a headache and a matched control participant were tested a minimum of 20 minutes after exercise to reduce the known effect of fatigue on BESS performance (Susco et al., 2004; Wilkins et al., 2004), using the same order administered during baseline testing. Testing took place in an environment free from distractions.

The Standardized Assessment of Concussion (SAC) test is a tool used for the detection of a concussion. It contains four parts to it: orientation, memory, concentration, and delayed recall (McCrea et al., 2000). It is an easy test that has the ability to be administered on the sidelines and only takes approximately five minutes to complete (Koscs, Kaminski, Swanik, Edwards, 2009). The test ranges from 0 to 30 points with lower scores showing more neurocognitive impairment (McCrea et al., 2000) (see Appendix D). Three forms of the test are available. Form A was used during baseline testing, and form B was used at follow-up.

The GSC is a questionnaire that allows the athlete to record the presence and severity of symptoms they are experiencing. Symptoms that are used are blurred vision, dizziness, drowsiness, excess sleep, easily distracted, fatigue, feeling "in a fog", feeling "slowed down, headache, inappropriate emotions, irritability, loss of consciousness, loss of orientation, memory problems, nausea, nervousness, personality change, poor balance, poor concentration, ringing in ears, sadness, seeing stars, sensitivity to light, sleep disturbance, vacant stare and vomiting (Guskiewicz et al., 2004). These symptoms are rated on a seven-point scale from 0 (no symptom experienced) to 6 (very severe) (see Appendix E). Administration of this test was performed by having the athlete complete the questionnaire on their own; however, an athletic trainer was available if questions arose.

The BESS is used to test postural stability. This is performed by having an athlete stand on flat and foam surfaces in a variety of positions, double leg, single leg and tandem stance. The nondominant foot was used in the single stance and as the rear foot in the tandem stance. Dominance can be determined by asking which leg is used to kick a ball. Six trials were then run (3 on firm and 3 on foam) using each stance. Each stance was recorded for 20 seconds while the subject's eyes were closed. A one point deduction was noted if one was to do any of the following: lift hand off iliac crest, open eyes, step, stumble or fall, move the hip into more than 30 degrees of flexion or abduction, lift the forefoot or heel or remain out of the test position for more than 5 seconds (Riemann et al., 1999).

CHAPTER 4: MANUSCRIPT

Abstract

Headache Does Not Predict Sideline Neurostatus or Balance in High School Football Players

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Context: Headache is reported to be the most common concussion related symptom. This has resulted in a heavy reliance on symptoms for the sideline assessment of concussive injuries. It is unclear however, if all athletes reporting headache demonstrate impairment in other commonly evaluated concussion domains. **Objective**: To determine the relationship between those with and without a headache resulting from football participation on neurostatus and balance. **Design:** A two group repeated-measures design. **Setting**: Three high schools in central Illinois. **Participants:** Varsity football athletes (N=32; age 16.3±0.8 years, range 16-18; weight 82.8±21.8 kg; height 177.0±7.5 cm), participated in this study. **Interventions:** All athletes completed a baseline evaluation of the Graded Symptom Checklist (GSC), Balance Error Scoring System (BESS) and Standardized Assessment of Concussion (SAC). Athletes reporting a headache (n=16) following a game or practice were re-administered the same test battery, as well control participants (non-headache: n=16) matched for age, playing position, weight and height. **Main Outcome Measures:** Performance on the GSC, BESS and SAC were evaluated using group by time repeated measures analysis of variance. Significance was noted when $p<0.05$. **Results:** Following football participation, total GSC scores increased significantly ($p=.004$) in the headache group (8.1±8.9 to 16.1±15.3), but significantly decreased ($p=.01$) in the non-headache group (6.1±7.0 to 3.1±4.4). A significant decrease ($p<.000$) in BESS

performance was noted in both groups: headache (15.0 ± 7.4 to 20.3 ± 8.9) and non-headache (13.3 ± 6.7 to 18.1 ± 6.7). No significant differences were noted on SAC performance ($p>0.05$). **<u>Conclusions</u>:** Performance on common concussion assessment tools does not appear to be influenced by athlete reports of football related headache. These findings indicate that the use of headache, exclusively or in combination with other concussion related symptoms, is not a valid marker of the injury. This supports previous works suggesting clinicians should adopt a multifaceted approach to concussion management. Further, physical exertion appears to have an effect on BESS performance independent of symptoms, suggesting careful interpretation of BESS scores when administered on the sideline.

Introduction

A concussion is a complex pathophysiological process induced by traumatic biomechanical forces that affects the brain, and induced by traumatic biomechanical forces (Aubry et al., 2002). It is estimated that between 1.6 and 3.8 million sport-related concussions occur each year in the United States (Langlios et al., 2006). Second only to motor vehicle accidents, sports, especially football, is one of the leading causes for traumatic brain injuries in people age 15 to 24 years old (Sosin et al., 1996).

High school athletics currently ranks as the largest athletic population in the United States with almost 7.2 million participants and over 1 million of them football athletes (NFHS, 2006). At the interscholastic level, between 5.5% (Powell & Barber-Foss, 1999) and 8.9% (Gessel et al., 2007) report sustaining a concussion which is a dramatic decrease from 24% reported in 1977 (Gerberich et al., 1983). This is thought to be due to a variety of reasons such as implementation of the National Operating Committee for Safety in Athletic Equipment (NOCSAE) helmet protection standards in 1980 (Powell & Barber-Foss, 1999), spearing being outlawed in 1976, player education on the effects of multiple concussions, reduction of physical contact time during practice, and clinician awareness of returning players to competition while symptomatic (Guskiewicz et al. 2000). Others feel the decrease is attributed to underreporting, which results from a lack of education about concussions and the pressure to perform (Gessel et al., 2007; McCrea et al., 2004).

For those reasons, it is especially important for the testing of concussions to be highly sensitive and effective. While most concussion scales focus on loss of consciousness (LOC) and amnesia for diagnosis (Cantu, 2001), LOC is reported in only 8.9% of the cases and amnesia in 27.7% (Guskiewicz et al., 2000). The National Athletic Trainers'

Association recommends that any athlete suspected of having a concussion be administered a clinical exam with tests of neurocognitive functioning, postural control and athlete reported symptoms used to support the diagnosis (Guskiewicz et al., 2004).

The Standardized Assessment of Concussion (SAC) is a brief neurostatus exam that can be quickly administered by medical personnel on the sideline to aid in the concussion diagnosis. The Balance Error Scoring System (BESS) is a measure of postural control that can similarly be administered on the sideline. The Graded Symptoms Checklist (GSC) uses a Likert scale to assess the presence and severity of symptoms. A one point decrease in a SAC exam from baseline testing to post-injury (Barr & McCrea, 2001) or performing three or more errors during a BESS exam has been shown to be significant enough to diagnose a concussion (Valovich McLeod et al., 2006). When used in conjunction immediately following injury, the GSC, SAC, and BESS are 94% sensitive to concussion (McCrea et al., 2005).

Symptom checklists are the most commonly employed assessment tool (Notebaert & Guskiewicz, 2005), but reporting can vary widely between individuals. Headache however, has been reported as a consistent concussion marker with 86% of high school and college athletes reporting a headache following a concussion (Guskiewicz et al., 2000). On the contrary, 35% of athletes report experiencing exercise related headaches that are unrelated to concussion (Williams & Nukada, 1994). These data provide conflicting information in regards to the management of a suspected concussive injury. Regardless, proper medical care would dictate that those reporting symptoms would necessitate further assessment to rule out concussion. Therefore, the purpose of this investigation is to elucidate the relationship between headache resulting from interscholastic football participation and athlete reports of concussion like symptoms (ie The Graded Symptoms Checklist (GSC)), postural control (BESS) and neurostatus (SAC).

Methods

Subjects were comprised of varsity football players from three high schools located in the central Illinois area. Athletes ranged from 16 to 18 years of age. Subjects allowed to participate in the study completed an inclusion/exclusion form and consent and assent form (see Appendixes A, B and C). All participants read and signed a University of Illinois Institutional Review Board informed consent document prior to testing. Preseason measurements of height, weight, and primary position played were recorded prior to the start of the season. This information was used to match players of the same demographic information for comparison between an athlete experiencing a headache and one that was not. Subjects were matched in order of importance: age, position played, weight and height. The control subjects ages were matched by year of birth, positions were matched by grouping subjects into skilled vs. lineman as well as offense vs. defense, weight was matched ± 20 pounds and height was matched ± 2 inches.

Baseline measurements of the GSC, SAC and BESS were administered prior to the start of the season. To decrease variability, the same individual administered either the BESS or SAC during baseline testing as well as at follow-up at each site. Subjects reporting a headache and a matched control participant were tested a minimum of 20 minutes after exercise to reduce the known effect of fatigue on BESS performance (Susco et al., 2004; Wilkins et al., 2004), using the same order administered during baseline testing. Testing took place in an environment free from distractions.

The Standardized Assessment of Concussion (SAC) test is a tool used for the detection of a concussion. It contains four parts to it: orientation, memory, concentration, and delayed recall (McCrea et al., 2000). It is an easy test that has the ability to be administered on the sidelines and only takes approximately five minutes to complete (Koscs, Kaminski, Swanik, Edwards, 2009). The test ranges from 0 to 30 points with lower scores showing more neurocognitive impairment (McCrea et al., 2000) (see Appendix D). Three forms of the test are available. Form A was used during baseline testing, and form B was used at follow-up.

The GSC is a questionnaire that allows the athlete to record the presence and severity of symptoms they are experiencing. Symptoms that are used are blurred vision, dizziness, drowsiness, excess sleep, easily distracted, fatigue, feeling "in a fog", feeling "slowed down, headache, inappropriate emotions, irritability, loss of consciousness, loss of orientation, memory problems, nausea, nervousness, personality change, poor balance, poor concentration, ringing in ears, sadness, seeing stars, sensitivity to light, sleep disturbance, vacant stare and vomiting (Guskiewicz et al., 2004). These symptoms are rated on a seven-point scale from 0 (no symptom experienced) to 6 (very severe) (see Appendix E). Administration of this test was performed by having the athlete complete the questionnaire on their own; however, an athletic trainer was available if questions arose.

The BESS is used to test postural stability. This is performed by having an athlete stand on flat and foam surfaces in a variety of positions, double leg, single leg and tandem stance. The nondominant foot was used in the single stance and as the rear foot in the tandem stance. Dominance can be determined by asking which leg is used to kick a ball. Six trials were then run (3 on firm and 3 on foam) using each stance. Each stance was recorded for 20 seconds while the subject's eyes were closed. A one point deduction was noted if one was to do any of the following: lift hand off iliac crest, open eyes, step, stumble or fall, move the hip into more than 30 degrees of flexion or abduction, lift the forefoot or heel or remain out of the test position for more than 5 seconds (Riemann et al., 1999).

Statistical Analysis

Performance on the GSC, BESS and SAC were evaluated using group by time repeated measures analysis of variance (ANOVA). Significant main effects were further analyzed by comparing the means of the two groups and two time points. Significance was noted when $p<0.05$. Data was analyzed using SPSS software (version 16.0, SPSS Inc., Chicago, IL).

Results

Descriptive analysis of the 32 subjects in the study can be found in Table 1. Further analysis was performed and significance was set at $p<0.05$. ANOVA results indicated no significant differences in GSC, BESS, or SAC performance between groups at baseline. At follow-up testing, there were significant group differences on the GSC ($F_{1,30}=10.81$, $p=0.003$). There were also significant time effects on the BESS ($F_{1,30}=22.89$, $p<0.00$).

Table 1. Descriptive analysis for the 32 subjects reported in average and standard deviation

Group	# of Subjects	Age (yr)	Height (cm)	Weight (kg)	Previous History of Concussion
Headache	16	16.31±0.79	178.83±7.77	87.23±20.77	0.46±0.66
Non-headache	16	16.38±0.72	175.46±7.42	82.69±15.01	0.50±0.97
Total	32	16.34±0.75	177.15±7.67	84.99±17.99	0.48±0.82

Symptoms were combined to give a total GSC score (Table 2). These scores were found to increase significantly from baseline to follow-up ($p=0.004$) in the headache group (8.06 ± 8.87 to 16.06 ± 15.29), but decreased significantly ($p=0.01$) in the non-headache group (6.81 ± 7.40 to 3.00 ± 4.34) (Figure 1). However, no significance was noted between the two groups.

Table 2: Number of people reporting symptoms for each group across both time points.

Symptom	Non-Headache Baseline	Non-Headache Follow-Up	Headache Baseline	Headache Follow-Up
Blurred Vision	4	3	1	5
Drowsiness	2	1	3	5
Excess Sleep	1	0	0	3
Easily Distracted	4	3	6	3
Fatigue	4	5	5	7
Feel "in a fog"	0	2	0	4
Feel "slowed down"	2	3	1	5
Headache	4	0	7	16
Inappropriate Emotions	0	0	0	2
Irritability	4	1	5	4
Loss of Consciousness	0	0	0	0
Loss of Orientation	0	0	2	1
Memory Problems	6	2	3	5
Nausea	0	0	1	4
Nervousness	5	0	3	1
Personality Change	0	1	1	1
Poor Balance/Coordination	7	1	3	3
Poor Concentration	4	1	4	4
Ringing in Ears	0	0	1	5
Sadness	0	1	0	0
Seeing Stars	0	0	0	1
Sensitivity to Light	1	0	0	1
Sensitivity to Noise	1	2	2	1
Sleep Disturbance	0	0	4	2
Vacant Stare/Glassy Eyed	2	1	0	0
Vomiting	0	0	0	1

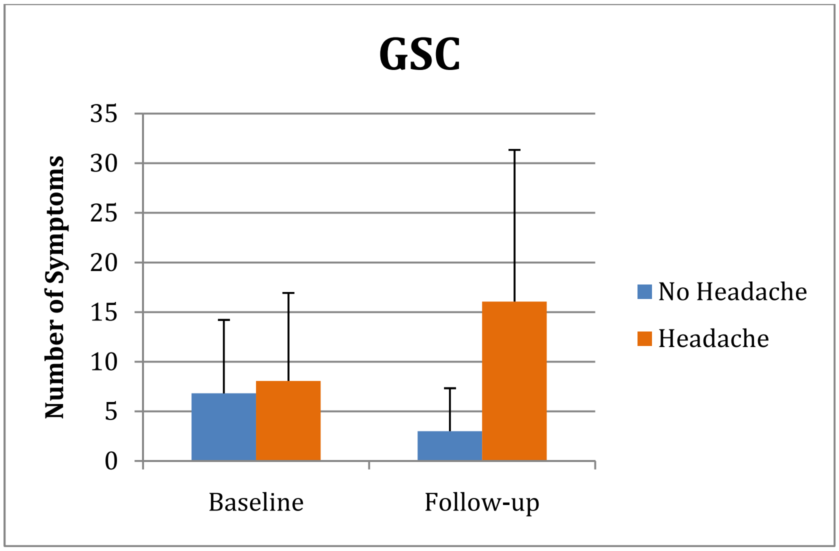

Figure 1. Total symptoms as reported on the GSC.

There was also a significant performance decrease ($p<.000$) in both groups when looking at BESS performance across time. The headache group (14.94±7.43 to 20.31±8.87) and non-headache group (13.31±6.72 to 18.13±6.74) both performed worse during the follow-up exam, but no significance was found between the two groups (Figure 2).

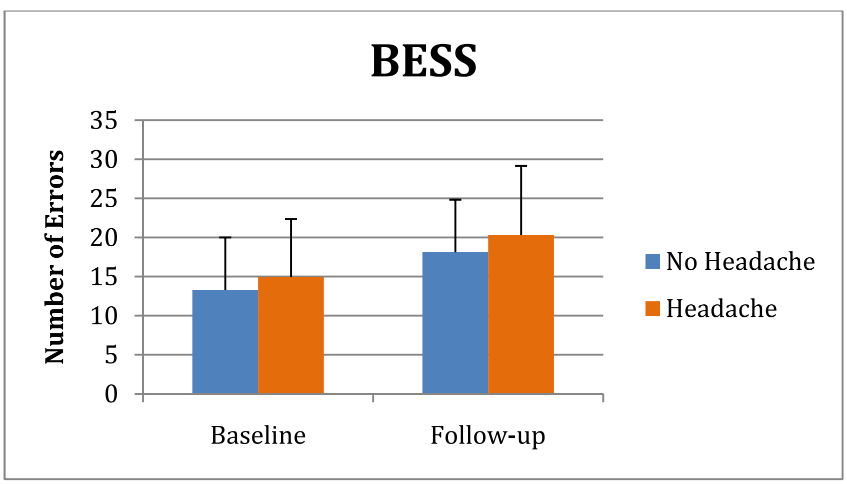

Figure 2. Total number of errors performed on the BESS.

The SAC test revealed no significant differences both across time and between groups. The headache group had a score of 24.75±2.91 out of 30 at baseline and

24.81±3.02 at follow-up. The non-headache group scores were 24.50±2.90 to 24.88±4.79 from baseline to follow-up (Figure 3).

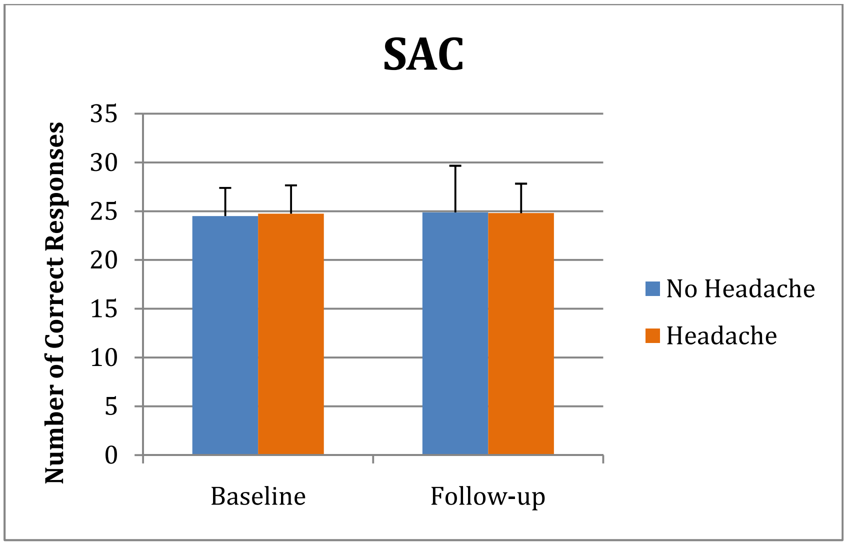

Figure 3. Total number of correct responses on the SAC.

Discussion

The main purpose of this study was to establish the relationship between those with and without a headache resulting from football participation on neurostatus and balance. It was hypothesized that athletes who reported a headache following exercise would perform the same on the neurocognitive and balance tasks compared to baseline; as well as no significant change in the reported symptoms. Overall, our results support our hypothesis in that headache is not a good predictor of concussion when compared to the non-headache group. Nevertheless, not all of the results were as expected. Both groups completing the SAC had the same score at baseline and follow-up; however, both groups experienced a significant increase in the number of BESS errors over the two time points. Furthermore, the headache group saw an increase in symptoms on the GSC, while non-headache group decreased.

Previous literature states that headache is the number one reported symptom of a concussion and should therefore warrant further evaluation when a headache is present (Gessel et al., 2007; Guskiewicz et al., 2003; Guskiewicz et al., 2000; Packard, 1999). Those reporting a headache did have an increase in other symptoms when compared to baseline; however, the non-headache group's symptoms decrease. The symptoms that increased following a headache include: blurred vision, drowsiness, excessive sleep, fatigue, feeling "in a fog", feeling "slowed down", inappropriate emotions, memory problems, nausea, ringing in the ears, seeing stars, sensitivity to light and vomiting.

This increase could be due to a variety of factors. Patel et al. (2007) report that dehydration can greatly influence an athlete's symptoms and can resemble that of a concussed athlete's symptoms with a feeling of being slowed down, increased fatigue/drowsiness, difficulty concentrating, balance problems, dizziness, and headache. Blau et al. (2004) also report that impaired concentration and irritability can also accompany a headache due to water-deprivation. Therefore, it is possible that our athletes were in a dehydrated state during the post-session testing.

Another reason for the increase may be due to over-endorsement. One study suggests that patients might be over-reporting their symptoms as more of an expectation of what is supposed to happen rather than what actually is occurring (Iverson, Brooks, Ashton, Lange, 2009). Our study used a checklist and asked the athlete to record their own symptoms. Iverson et al. (2009) also propose that when a symptomatic person is presented with a checklist, the items on the list contribute to the idea that those items are of importance and therefore more inclined to report them when in fact he/she may not be experiencing them.

In addition to significantly increased symptoms in the headache group, both groups demonstrated significantly worse balance during follow-up testing. The significant increase in errors from baseline to follow-up was the equivalent across groups as there was no statistically significant difference between the groups at either time point. While this study could not fully elucidate the underpinnings of this change, several mechanisms may play a role. Numerous studies say that the BESS test is negatively affected by muscle fatigue and therefore must be administered 20 minutes post exercise to allow postural control to return to normal following activity (Susco et al., 2004; Wilkins et al., 2004). More recently, Fox et al. (2008) reported that balance can be restored in as early as 13 minutes post exercise. In our study, the BESS test was the last test performed and was done so following a period of rest after the game. It is estimated that the testing took place approximately 20 to 25 min post exercise, which should have allowed enough time for postural control to return to normal. However, previous studies used relatively short duration fatigue protocols, whereas the follow-up testing in our study took place after 2 to 3 hours of game or practice activities (Fox, et al., 2008; Susco et al., 2004; Wilkins et al., 2004). This longer duration of physical activity may have resulted in a greater degree of central and peripheral fatigue than what was induced in previous investigations. Thus, longer periods of rest may be needed to gain the most reliable BESS measures.

Lastly, there were not any significant findings on the SAC test in either group. A few studies discuss the possibility of a learning effect on the SAC test; however they found that after repeated administration a practice effect did not occur (Valovich et al., 2003; Valovich McLeod et al., 2004). Two different versions were administered at baseline and follow-up, and even though they are both very similar, this could have played a role in the similar scores.

Limitations

Finally, all three tests strongly relied on the athletes' best effort during each testing period. Even though they were instructed to try their best, the follow-up testing was sometimes performed post game and the others post practice. The moods and related effort varied between these two events; even more so depending upon how they performed in practice or the result of the game.

Conclusion

Performance on common concussion assessment tools does not appear to be influenced by athlete reports of football related headache. These findings indicate that the use of headache, exclusively or in combination with other concussion related symptoms, is not a valid marker of the injury. This supports previous works suggesting clinicians should adopt a multifaceted approach to concussion management. Further, physical exertion appears to have an effect on BESS performance independent of symptoms, suggesting careful interpretation of BESS scores when administered on the sideline.

Appendix A: Cover Letter

UNIVERSITY OF ILLINOIS
AT URBANA-CHAMPAIGN

Department of Kinesiology and Community Health

College of Applied Health Sciences
Louise Freer Hall
906 South Goodwin Avenue
Urbana, IL 61801

To Whom It May Concern:

Dr Steve Broglio, Matthew Nohren, Bridget Van Boxtel, Karla Wessels, and Matthew Sabin are inviting your child to participate in a research study that we are conducting to gain a better understanding of headaches. Specifically, we are trying to gain knowledge on how the body and mind react when one is experiencing a headache resulting from football participation. Your child's participation is extremely important in advancing knowledge in this area and is greatly appreciated. **Your child's participation will not impact playing time or any clinical care that he/she may receive in the future in any way.** The information obtained in the study would be strictly confidential and will not be released to any individual or group under any circumstances. All identifying information will be removed from any publications or presentations. All information obtained in the study would be reported as combined data without identifying individuals.

The study involves the completion of a memory test (SAC), a balance test (BESS), and a report of physical symptoms. These will be administered before your child begins the football season, as well as when a headache is present. Athletes with a headache will be asked to retake the tests after a specific practice or game when a headache is experienced. These data will be used to compare the findings with the preseason results. All athletes experiencing a headache will only be asked to repeat the tests once during the season. Some athletes that do not sustain a headache during the football season may be asked to complete the assessments so the results can be compared to a teammate. Total participation time to complete the tests is approximately 15 minutes.

If you are interested in participating please complete the consent and assent forms attached to this letter. If you have any questions about participation, please call Dr Steve Broglio at 217-244-1830 or email: broglio@illinois.edu.

Sincerely,

Steven P. Broglio, PhD, ATC
Matthew Nohren, ATC
Bridget Van Boxtel, ATC
Karla Wessels, ATC
Matthew Sabin, ATC

telephone 217-333-2461• fax 217-244-7322

Appendix B: Consent Form

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

Department of Kinesiology
Louise Freer Hall
906 South Goodwin Avenue
Urbana, IL 61801-3895

PARENTAL CONSENT
Headache in football

Thank you for considering to allow your child to participate in the research study titled, **Headache in football**, which is being conducted by Dr. Steve Broglio (217-244-1830) Bridget Van Boxtel, Matthew Nohren, Matthew Sabin, and Karla Wessels of the Department of Kinesiology and Community Health. Your child's participation in this research is voluntary. The decision to participate, decline, or withdraw from participation will have no effect on grades, status, or future relations with the high school, or the University of Illinois. You and your child have the right to refuse participation or may withdraw consent at any time without penalty from coaching staff.

PURPOSE:

The purpose of this investigation is to understand the relationship between a football induced headache and measures of balance and memory. The results of this study will be used to improve the medical care for all high school football athletes.

PROCEDURES:

Student athletes who participate in this study, and whose parent or guardian give their consent, will complete three tests at the start of the study for baseline information. They are the Standardized Assessment of Concussion (SAC), the Balance Error Scoring System (BESS), and a Symptom Inventory, which is a list of concussion-related symptoms. More information on each test is described below. Following a game or practice, the student athlete may be asked to complete the same tests again if he reports a headache to one of the researchers or if he is selected as a control participant. Total time to complete the tests is 15 min on each occasion.

1. The Standardized Assessment of Concussion (SAC) contains four sections: orientation, memory, concentration and delayed recall. For each section the athlete will be asked by an investigator to recall the day/time, a series of words, or a string of numbers. Time to complete the SAC is approximately 5 minutes.

2. The BESS consists of three different stances (double leg, single leg, and tandem stance) on a firm and foam surface. All testing will be completed with the eyes closed and with the hands on hips. Total time to complete one BESS assessment is approximately five minutes

3. The symptom inventory will ask if the athlete is experiencing symptoms commonly associated with concussion. This will take less than 2 minutes to complete.

RISKS AND BENEFITS

Student athletes who participate in this study may benefit from state-of-the-art assessment of concussive injuries. In addition, he will gain a better understanding and knowledge of concussion. At the conclusion of the study, the athlete may request to receive written or verbal information about performance on the SAC and BESS tests.

There are no more than minimal risks associated with taking the SAC, BESS or symptom inventory tests. The athlete may find the test challenging but he will not be placed in any danger for injury or discomfort. He may suspend testing at any time.

CONFIDENTIALITY

The athlete's participation in this study and the results of this participation will not be given to anyone outside the research study group. To ensure privacy and confidentiality, a code number will be assigned to each participant, and all data collected will be recorded using only the code number. Some data may be discussed at professional meetings or in publications, but at no time will any participant be identified by name. Any data used for research will not be released in any individually identifiable form without prior written consent, unless otherwise required by law.

CONTACT INFORMATION

There are no costs to you for taking part in this study and all testing will occur at no cost to you or your child.
There is no compensation for participation in this study.

If at any time you have questions about this research project, or if you experience any problems related to your participation in the project, please feel free to contact the responsible project investigator: Steven P. Broglio PhD, Department of Kinesiology and Community Health, 906 S. Goodwin Ave, Urbana, IL 61801, 217.244.1830, Broglio@uiuc.edu.

If you would like to speak to someone about your child's rights as a participant in this study, you may contact the University of Illinois Institutional Review Board at 217-333-2670 or irb@illinois.edu. You may call the University of Illinois IRB collect if you identify yourself as a research participant.

I understand that I am agreeing by my signature on this form for my child to take part in this research project and understand that I will receive a signed copy of this consent form for my records.

__Steven P. Broglio____	______________________________	___________
Name of Researcher	Signature	Date
__________________________		
Name of Participant		
__________________________	______________________________	___________
Name of Parent/Guardian	Signature	Date

Please sign both copies, keep one and return one to the researcher.

Appendix C: Assent Form

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

Department of Kinesiology
Louise Freer Hall
906 South Goodwin Avenue
Urbana, IL 61801-3895

PARTICIPANT ASSENT
Headache in football

Thank you for considering participating in the research study titled, **Headache in football**, which is being conducted by Dr. Steve Broglio (217-244-1830) Bridget Van Boxtel, Mathew Nohren, Mathew Sabin, and Karla Wessels of the Department of Kinesiology and Community Health. Your participation in this research is voluntary. The decision to participate, decline, or withdraw from participation will have no effect on grades, status, or future relations with the high school, or the University of Illinois. You have the right to refuse participation and may withdraw consent at any time without penalty from the coaching staff.

PURPOSE:

The purpose of this investigation is to understand the relationship between a football induced headache and measures of balance and memory. The results of this study will be used to improve the medical care for all high school football athletes.

PROCEDURES:

If you agree to participate in this study, you will complete three tests at the start of the study for baseline information. They are the Standardized Assessment of Concussion (SAC), the Balance Error Scoring System (BESS), and a Symptom Inventory, which is a list of concussion-related symptoms. More information on each test is described below. Following a game or practice you may be asked to complete the same tests again if you report a headache to one of the researchers or if you are selected as a control participant. Total time to complete the tests is 15 min on each occasion.

4. The Standardized Assessment of Concussion (SAC) contains four sections: orientation, memory, concentration and delayed recall. For each section you will be asked by an investigator to recall the day/time, a series of words, or a string of numbers. Time to complete the SAC is approximately 5 minutes.

5. The BESS consists of three different stances (double leg, single leg, and tandem stance) on a firm and foam surface. All testing will be completed with the eyes closed and with the hands on hips. Total time to complete one BESS assessment is approximately five minutes

6. The symptom inventory will ask if you are experiencing symptoms commonly associated with concussion. This will take less than 2 minutes to complete.

RISKS AND BENEFITS

If you participate in this study you may benefit from state-of-the-art assessment of concussive injuries. In addition, you will gain a better understanding and knowledge of concussion. At the conclusion of the study, you may request to receive written or verbal information about your performance on the SAC and BESS tests.

There are no more than minimal risks associated with taking the SAC, BESS or symptom inventory tests. You may find the test challenging but he will not be placed in any danger for injury or discomfort. You may stop testing at any time.

CONFIDENTIALITY

Your participation in this study and the results of this participation will not be given to anyone outside the research study group. To ensure privacy and confidentiality, a code number will be assigned to each participant, and all data collected will be recorded using only the code number. Some data may be discussed at professional meetings or in publications, but at no time will any participant be identified by name. Any data used for research will not be released in any individually identifiable form without prior written consent, unless otherwise required by law.

CONTACT INFORMATION

There are no costs to you for taking part in this study. There is no compensation for participation in this study.

If at any time you have questions about this research project, or if you experience any problems related to your participation in the project, please feel free to contact the responsible project investigator: Steven P. Broglio PhD, Department of Kinesiology and Community Health, 906 S. Goodwin Ave, Urbana, IL 61801, 217.244.1830, Broglio@uiuc.edu.

If you would like to speak to someone about your rights as a participant in this study, you may contact the University of Illinois Institutional Review Board at 217-333-2670 or irb@illinois.edu. You may call the University of Illinois IRB collect if you identify yourself as a research participant.

I understand that I am agreeing by my signature on this form to take part in this research project and understand that I will receive a signed copy of this consent form for my records.

__Steven P. Broglio____	______________________________	___________
Name of Researcher	Signature	Date
___________________________	______________________________	___________
Name of Participant	Signature	Date

Please sign both copies, keep one and return one to the researcher.

Appendix D: SAC Test

Standardized Assessment of Concussion (SAC)

1) ORIENTATION:

Month: ______________________ 0 1
Date: ______________________ 0 1
Day of week: ______________________ 0 1
Year: ______________________ 0 1
Time (within 1 hr.): ______________ 0 1

Orientation Total Score __________/ 5

2) IMMEDIATE MEMORY: (all 3 trials are completed regardless of score on trial 1 & 2; total score equals sum across all 3 trials)

List	Trial 1	Trial 2	Trial 3
Word 1	0 1	0 1	0 1
Word 2	0 1	0 1	0 1
Word 3	0 1	0 1	0 1
Word 4	0 1	0 1	0 1
Word 5	0 1	0 1	0 1
Total			

Immediate Memory Total Score ____ / 15

(Note: Subject is not informed of Delayed Recall testing of memory)

NEUROLOGICAL SCREENING:

Loss of Consciousness: (occurrence, duration)

Pre- & Post-traumatic Amnesia: (recollection of events pre- and post-injury)

Strength:

Sensation:

Coordination:

3) CONCENTRATION:

Digits Backward (If correct, go to next string length. If incorrect, read trial 2. Stop after incorrect on both trials)

4-9-3	6-2-9	__________	0 1
3-8-1-4	3-2-7-9	__________	0 1
6-2-9-7-1	1-5-2-8-6	__________	0 1
7-1-8-4-6-2	5-3-9-1-4-8	__________	0 1

Months in reverse order: (entire sequence correct for 1 point)
Dec-Nov-Oct-Sep-Aug-Jul
Jun-May-Apr-Mar-Feb-Jan _______ 0 1

Concentration Total Score _____ / 5

EXERTIONAL MANEUVERS
(when appropriate)

5 jumping jacks 5 push-ups
5 sit-ups 5 knee-bends

4) DELAYED RECALL

Word 1 0 1
Word 2 0 1
Word 3 0 1
Word 4 0 1
Word 5 0 1

Delayed Recall Total Score _____ / 5

Summary of Total Scores :

Orientation _____/ 5
Immediate Memory _____/ 15
Concentration _____/ 5
Delayed Recall _____/ 5

Overall Total Score ___________/ 30

McCrea, Kelly & Randolph, 2000

Appendix E: Graded Symptoms Checklist

Graded Symptoms Checklist

Symptom	Presence		Mild		Moderate		Severe	
Blurred Vision	Yes	No	1	2	3	4	5	6
Drowsiness	Yes	No	1	2	3	4	5	6
Excess Sleep	Yes	No	1	2	3	4	5	6
Easily Distracted	Yes	No	1	2	3	4	5	6
Fatigue	Yes	No	1	2	3	4	5	6
Feel “in a fog”	Yes	No	1	2	3	4	5	6
Feel “slowed down”	Yes	No	1	2	3	4	5	6
Headache	Yes	No	1	2	3	4	5	6
Inappropriate Emotions	Yes	No	1	2	3	4	5	6
Irritability	Yes	No	1	2	3	4	5	6
Loss of Consciousness	Yes	No	1	2	3	4	5	6
Loss of Orientation	Yes	No	1	2	3	4	5	6
Memory Problems	Yes	No	1	2	3	4	5	6
Nausea	Yes	No	1	2	3	4	5	6
Nervousness	Yes	No	1	2	3	4	5	6
Personality Change	Yes	No	1	2	3	4	5	6
Poor Balance/Coordination	Yes	No	1	2	3	4	5	6
Poor Concentration	Yes	No	1	2	3	4	5	6
Ringing in Ears	Yes	No	1	2	3	4	5	6
Sadness	Yes	No	1	2	3	4	5	6
Seeing Stars	Yes	No	1	2	3	4	5	6
Sensitivity to Light	Yes	No	1	2	3	4	5	6
Sensitivity to Noise	Yes	No	1	2	3	4	5	6
Sleep Disturbance	Yes	No	1	2	3	4	5	6
Vacant Stare/Glassy Eyed	Yes	No	1	2	3	4	5	6
Vomiting	Yes	No	1	2	3	4	5	6

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